**3GPP TSG-RAN WG4 Meeting#109 R4-231xxxx**

**Chicago, USA 13th Nov – 17th Nov, 2023**

**Agenda item: 8.7.4**

**Source:** Moderator (Qualcomm)

**Title:** Topic summary for [109][318]NR\_FR2\_multiRX\_DL\_Demod

**Document for:** Information

# Introduction

Based on the open issues, the discussions can proceed as follows:

* 1st priority: Discuss and converge on the remaining issues concerning general aspects, such as receiver assumptions.
* 2nd priority: Agree on the remaining simulation assumptions and align simulation results for UE demodulation and CSI reporting test cases as well as discuss/agree on the draft CRs.

# Topic #1: General Aspects for FR2 Multi-Rx Demod

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318570 | Apple | **TR update**1. **RAN4 has made significant progress in demodulation side and involves an evaluation phase before defining the requirements.**
2. **In RAN#101 it was recommended to further discuss TRP update to capture demod evaluation in RAN4.**
3. Expand the scope of TR 38.751 to include the outcome of the evaluation phase for defining demodulation requirements.- Correlation Matrix derivation/ definition- Performance evaluation of different configurations – cross talk levels, mTRP schemes, UE processing
4. Revise the title of the TR in RAN#102 with a revised WID to include demod related evaluation and study.

**Channel Model and Correlation matrix** 1. **The agreed channel model is based on per TRP-panel channel.**
2. **We would typically define antenna configuration and channel model from TRP to UE.**
3. **There is no agreed definition of panel in RAN4.**
4. **The correlation matrix is defined across all TRPs and Rx panels.**
5. Define antenna configuration, channel model and spatial correlation matrix per TRP to UE.
6. Seek input from TE vendor on how the channel model and correlation matrix should be defined for multi-RX demod requirements.

**Assumptions for requirements**1. Select configuration for defining demod requirements for multi-RX based on evaluation results and feasibility.

**UE Feature**1. **It is FFS if requirements will be defined with joint processing.**
2. If it is agreed to define requirements with joint processing introduce the separate UE capability for joint processing with sDCI SDM transmission scheme and joint processing with mDCI overlapping transmission scheme
3. If it is agreed to define requirements with joint processing introduce the following UE feature(s) -- UE capability for joint processing with sDCI SDM transmission scheme and/or UE capability for joint processing with mDCI overlapping transmission scheme- Optional without capability signaling- Pre-requisite FG: 16-2c: Simultaneous reception with different QCL Type-D- Granularity: Per FSPC
 |
| R4-2318790 | Nokia | **Receiver assumption for mDCI case**1. **Joint processing capable receiver is required to properly define the requirements under medium/high crosstalk (**$ρ$ **= -9dB) and MCS candidate values for mDCI case.**
2. Introduce joint processing receiver requirements for mDCI fully overlapping cases.

**Receiver assumption for sDCI SDM case**1. **Joint processing capable receiver is required to properly define the requirements under low/med crosstalk** $ρ$**=-12/-9dB and MCS candidate values for sDCI case. We also see that in practical deployment scenarios it is likely that for sDCI, TRPs will be co-located resulting in high cross-talk.**
2. Introduce joint processing receiver requirements for the sDCI SDM case.

**MCS and layer selection for mDCI fully overlapping case**1. **For each one of the rank configurations (i.e., rank 1+1 or 2+2), it is appropriate to select the most suitable crosstalk factor** $ρ$ **and MCS values based on the simulation results. Note it is preferable to select only one crosstalk factor for each such rank scenario.**
2. **Based on our simulation results, we do not see it feasible to define requirements for mDCI fully overlapping case with separate processing using ρ = -9dB or higher.**
3. **Based on our simulation results, it is feasible to define requirements for mDCI fully overlapping case with separate processing with the following configurations:1+1: MCS 17, ρ = -12dB2+2: MCS 13, ρ = -12dB**
4. Define requirements mDCI fully overlapping case with separate processing for:1+1: MCS 17, ρ = -12dB2+2: MCS 13, ρ = -12dB
5. Further discuss test cases with joint processing using higher values of ρ (-9dB and/or -6dB) if joint processing is agreed to be introduced.

**TxEVM**1. RAN4 shall not consider TE TxEVM for the derivation of final requirement SNR values.A value of 2% TE TxEVM shall be considered in FR1 and independently of the modulation order, to limit the MCS choice to stay below 1dB degradation, when testing with a TE having such an innate TxEVM.

**TR update**1. **38.101-4 will only contain the final correlation and cross-talk mode but will not include additional relevant information from the evaluation phase. Therefore, such information can be alternatively captured in TR38.751 for future reference.**
2. RAN4 to extend the TR 38.751 scope by adding relevant evaluation phase outcomes aiming to properly defining the respective multiRx demodulation and CSI requirements.
 |
| R4-2320233 | Huawei, HiSilicon | 1. Define requirements based on separate processing for FR2 mDCI mTRP fully-overlapping case in Rel-18.
2. Define requirements based on separate processing for FR2 multi-Rx sDCI SDM case in Rel-18.
3. Consider Tx EVM at 6% for FR2 multi-Rx demodulation requirements.
4. Do not consider expanding the scope of TR 38.751 to include demodulation related evaluation and study.
 |
| R4-2318549 | MediaTek | **Proposal #1: We propose to consider separate processing receiver assumption for mDCI fully overlapping only to (1+1) scenario due to too high isolation requirement for (2+2).****Proposal #2: We are open to consider joint processing receiver assumption for mDCI fully overlapping and non‑overlapping to (2+2) scenarios if UE capability for joint processing is introduced.****Proposal #3: We propose to introduce UE capability for joint processing.****Proposal #4: We propose to consider separate processing receiver assumption for sDCI SDM only to (1+1) scenario due to too high isolation requirement for (2+2).****Proposal #5: We are open to consider joint processing receiver assumption for sDCI SDM to (2+2) scenario if UE capability for joint processing is introduced.****Proposal #6: We propose to introduce PDSCH requirements using MCS17 with rank 1+1 and ρ = -12dB in sDCI SDM with separate processing.****Proposal #7: We are ok to introduce PDSCH requirements using MCS17 with rank 1+1 and ρ = ‑6dB in sDCI SDM with joint processing with corresponding UE capability.****Proposal #8: We are ok to introduce PDSCH requirements using MCS13 with rank 2+2 and ρ = ‑6dB in sDCI SDM only for joint processing with corresponding UE capability.****Proposal #9: We propose to introduce PDSCH requirements using MCS17 with rank 1+1 and ρ = -12dB in mDCI fully overlapping with separate processing.****Proposal #10: We are ok to introduce PDSCH requirements using MCS17 with rank 1+1 and ρ = ‑6dB in mDCI fully overlapping with joint processing with corresponding UE capability.****Proposal #11: We are ok to introduce PDSCH requirements using MCS13 with rank 2+2 and ρ = ‑6dB in mDCI fully overlapping only for joint processing with corresponding UE capability.****Proposal #12: We propose to introduce PDSCH requirements using MCS13 with rank 2+2 and ρ = -12dB in mDCI non‑overlapping with separate processing.****Proposal #13: We are ok to introduce PDSCH requirements using MCS13 with rank 2+2 and ρ = ‑6dB in mDCI non‑overlapping with joint processing with corresponding UE capability.****Proposal #14: We are ok to consider expanding the scope of TR 38.751 to include demodulation related evaluation and study.****Proposal #15: We propose to follow NR FR2 OTA enhancements WI work for their final conclusions and take those into account when defining corresponding demodulation requirements.****Observation #1: New proposal refers to TRP-to-panel channel correlation matrix RMIMO similarly to the agreed model.****Observation #2: New proposal does not explicitly define per-TRP channels statically independent, whereas the agreed model does.****Observation #3: New proposal is mathematically equivalent to the agreed model if we assume per-TRP channels statically independent.****Proposal #16: We prefer the agreed model definition. However, we are also fine to define channel model and spatial correlation matrix per TRP to UE if preferred by majority of companies.****Proposal #17: We propose the following UE feature list for NR\_FR2\_multiRX\_DL-Perf** |
| R4-2318730 | Qualcomm | **Observation 1: Implementation complexity with joint processing scales exponentially compared to separate processing.****Observation 2: In contrast to FR1, FR2 involves a higher aggregated bandwidth, which contributes to additional implementation complexity from the UE side.****Proposal 1: Assume separate processing for mDCI receiver assumption in Rel-18 for both 1L+1L and 2L+2L cases.** **Proposal 2: Consider advanced receiver, such as joint processing that comes with higher implementation complexity in future releases.****Proposal 3: Assume separate processing for sDCI receiver assumption in Rel-18 for both 1L+1L and 2L+2L cases.****Observation 3: Peak throughput can’t be achieved for mDCI 2L+2L case with MCS13 for separate processing at -12 dB cross-talk power.****Proposal 4: Consider a cross-talk power of -15 dB or MCS 11 for mDCI 2L+2L case.****Observation 4: RAN4 is not conducting any exploratory demodulation studies in the context of FR2 multi-Rx WI.****Observation 5: All performance requirements including the agreed FR2 multi-Rx correlation model will be captured in 38.101-4 specification.****Proposal 5: Don’t consider expanding the scope of TR38.751.** |
| R4-2318767 | Qualcomm | **Draft CR to include the FR2 multi-Rx correlation model in the 38.101-4 specification** |

## Open issues summary

List of open issues

* Sub-topic 1-1 General aspects for FR2-1 multi-Rx chain DL reception
	+ Issue 1-1-1: Receiver assumption for mDCI fully-overlapping case.
	+ Issue 1-1-2: Receiver assumption for mDCI non-overlapping case.
	+ Issue 1-1-3: Receiver assumption for sDCI SDM case.
	+ Issue 1-1-4: MCS/layer/cross-talk for sDCI SDM case.
	+ Issue 1-1-5: MCS/cross-talk for mDCI fully overlapping 1+1 case.
	+ Issue 1-1-6: MCS/cross-talk for mDCI fully overlapping 2+2 case.
	+ Issue 1-1-7: MCS/layer/cross-talk for mDCI non overlapping case
	+ Issue 1-1-8: TxEVM
	+ Issue 1-1-9: Assumption on correlation model.
	+ Issue 1-1-10: Whether to adopt NT FR2 OTA enhancements when defining demodulation requirements.
	+ Issue 1-1-11: UE feature for joint processing (if introduced).
	+ Issue 1-1-12: TR update

### Sub-topic 1-1: General aspects for FR2-1 multi-Rx chain DL reception

**Issue 1-1-1: Receiver assumption for mDCI fully overlapping case.**

* Observations
	+ Observation 1 (Nokia):
		- * Joint processing capable receiver is required to properly define the requirements under medium/high crosstalk (ρ = -9dB) and MCS candidate values for mDCI case.
	+ Observation 2 (Qualcomm):
* Implementation complexity with joint processing scales exponentially compared to separate processing.
* In contrast to FR1, FR2 involves a higher aggregated bandwidth, which contributes to additional implementation complexity from the UE side.
	+ Observation 3 (Apple):
* Multi-DCI with 1 layer per TRP overlapping PDSCH is not severely impacted by cross talk with separate processing.
* Multi-DCI with 2 layers per TRP overlapping PDSCH is severely impacted by cross talk with separate processing.
* For multi-DCI with 1 or 2 layers per TRP overlapping PDSCH, joint processing is more robust to cross talk.
* Multi-DCI with overlapping PDSCH and 2 layers per TRP, only joint processing is feasible.
* Proposals:
* Option 1 (Nokia):
	+ - * Introduce joint processing receiver requirements for mDCI fully overlapping cases.
				+ Option 1b (MediaTek): Consider joint processing for only 2+2 scenario if UE capability is introduced.
* Option 2 (Apple):
	+ - * Select configuration for defining demod requirements for multi-RX based on evaluation results and feasibility.
* Option 3 (Huawei, Qualcomm, Ericsson):
	+ Define requirements based on separate processing for FR2 mDCI mTRP fully-overlapping case in Rel-18.
		- Option 3a (Qualcomm): Consider advanced receiver only in future releases.
		- Option 3b (MediaTek, Apple): Consider separate processing for only 1+1 scenario.
		- Option 3c Ericsson): Consider separate processing as far as ρ=-12dB.
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-2: Receiver assumption for mDCI non overlapping case.**

* Proposals:
* Option 1 (Ericsson):
	+ - Define single PDSCH demodulation requirements assuming separate processing for multi-DCI based non-overlapping scheme.
	+ Option 2 (MediaTek):
		- Consider joint processing receiver assumption for non-overlapping to (2+2) scenarios if UE capability for joint processing is introduced.
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-3: Receiver assumption for sDCI SDM case.**

* Observations
	+ Observation 1 (Nokia):
		- * Joint processing capable receiver is required to properly define the requirements under low/med crosstalk ρ=-12/-9dB and MCS candidate values for sDCI case. We also see that in practical deployment scenarios it is likely that for sDCI, TRPs will be co-located resulting in high cross-talk.
* Observation 2 (Apple):
	+ - Single-DCI SDM with 1 layer per TRP is not severely impacted by cross talk with separate processing.
		- Single-DCI SDM with 2 layers per TRP is severely impacted by cross talk with separate processing.
		- For single-DCI SDM with 1 or 2 layers per TRP, joint processing is robust to cross talk.
		- 4 layer transmission with sDCI SDM is only possible with joint processing.
* Proposals:
* Option 1 (Nokia):
	+ - * Introduce joint processing receiver requirements for the sDCI SDM case.
				+ Option 1b (MediaTek): Consider joint processing for only 2+2 scenario if UE capability is introduced.
* Option 2 (Huawei, Qualcomm):
	+ - * Define requirements based on separate processing for FR2 multi-Rx sDCI SDM case in Rel-18.
				+ Option 2b (MediaTek, Apple): Consider separate processing for only 1+1 scenario.
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-4: MCS/layer/cross-talk for sDCI SDM case.**

* Observations
* Observation 1 (Apple):
	+ - Single-DCI SDM with 1 layer per TRP is not severely impacted by cross talk with separate processing.
		- Single-DCI SDM with 2 layers per TRP is severely impacted by cross talk with separate processing.
		- For single-DCI SDM with 1 or 2 layers per TRP, joint processing is robust to cross talk.
		- 4 layer transmission with sDCI SDM is only possible with joint processing.
* Proposals
	+ Option 1 (MediaTek):
* Option 1a (Apple): 1+1, MCS17, ρ=-9dB with separate processing
* Option 1b: 1+1, MCS17, ρ=-6dB with joint processing with corresponding UE capability
* Option 1c: 2+2, MCS13, ρ=-6dB with joint processing with corresponding UE capability
	+ Option 2 (Ericsson):
* 1+1, MCS17, ρ=-6 dB with both separate and joint processing
* 2+2, MCS13, ρ=-12dB
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-5: MCS/cross-talk for mDCI fully overlapping 1+1 case.**

* Observations
	+ Observation 1 (Nokia):
		- For each one of the rank configurations (i.e., rank 1+1 or 2+2), it is appropriate to select the most suitable crosstalk factor ρ and MCS values based on the simulation results. Note it is preferable to select only one crosstalk factor for each such rank scenario.
		- Based on our simulation results, we do not see it feasible to define requirements for mDCI fully overlapping case with separate processing using ρ = -9dB or higher.
		- Based on our simulation results, it is feasible to define requirements for mDCI fully overlapping case with separate processing with the following configurations:
		1+1: MCS 17, ρ = -12dB
		2+2: MCS 13, ρ = -12dB
	+ Observation 2 (Apple):
		- Multi-DCI with non-overlapping PDSCH is not severely impacted by cross talk.
		- Multi-DCI with 1 layer per TRP overlapping PDSCH is not severely impacted by cross talk with separate processing.
		- Multi-DCI with 2 layers per TRP overlapping PDSCH is severely impacted by cross talk with separate processing.
		- For multi-DCI with 1 or 2 layers per TRP overlapping PDSCH, joint processing is more robust to cross talk.
		- Multi-DCI with overlapping PDSCH and 2 layers per TRP, only joint processing is feasible.
* Proposals
	+ Option 1 (Qualcomm, Apple, Nokia, MediaTek, Ericsson):
		- MCS 17, ρ = -12dB with separate processing
	+ Option 2 (MediaTek):
		- MCS17, ρ=-6dB with joint processing with corresponding UE capability

**Issue 1-1-6: MCS/cross-talk for mDCI fully overlapping 2+2 case.**

* Observations
	+ Observation 1 (Qualcomm):
		- Peak throughput can’t be achieved for mDCI 2L+2L case and MCS13 with per TRP independent processing at -12 dB cross-talk.
* Proposals
	+ Option 1 (Qualcomm):
		- Option 1a: MCS 13, ρ = -15dB or lower with separate processing
		- Option 1b: MCS 11 or lower, ρ = -12dB with separate processing
	+ Option 2 (Nokia):
		- MCS 13, ρ = -12dB with separate processing
		- Further discuss test cases with joint processing using higher values of ρ (-9dB and/or -6dB) if joint processing is agreed to be introduced.
	+ Option 3 (MediaTek):
		- MCS13, ρ=-6dB with joint processing with corresponding UE capability
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-7: MCS/layer/cross-talk for mDCI non overlapping case.**

* Proposals
	+ Option 1 (MediaTek): Define requirements mDCI non overlapping case for
		- Option 1a (Ericsson): 2+2, MCS13, ρ=-12dB with separate processing
		- Option 1b: 2+2, MCS13, ρ=-6dB with joint processing with corresponding UE capability
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-8: TxEVM.**

* Observations
	+ Observation 1 (Nokia):
		- * Test requirement parameters usually do not capture (Tx)EVM and TEs don’t add TxEVM during test. Considering TxEVM in requirement derivation is resulting SNR relaxation without corresponding RF impairment in the conformance test.
* Proposals
	+ Option 1 (Huawei): Consider Tx EVM at 6% for FR2 multi-Rx demodulation requirements.
	+ Option 2 (Nokia): RAN4 shall not consider TE TxEVM for the derivation of final requirement SNR values. A value of 2% TE TxEVM shall be considered in FR1 and independently of the modulation order, to limit the MCS choice to stay below 1dB degradation, when testing with a TE having such an innate TxEVM
* Moderator’s note: It was agreed to consider 6% TxEVM for 64QAM modulation during the last meeting.
* Recommended WF:
	+ Consider 6% TxEVM.

 **Issue 1-1-9: Assumption on correlation model.**

* Observations
	+ Observation 1 (Apple):
		- * The agreed channel model is based on per TRP-panel channel.
			* We would typically define antenna configuration and channel model from TRP to UE.
			* There is no agreed definition of panel in RAN4.
			* The correlation matrix is defined across all TRPs and Rx panels Proposals:
	+ Observation 2 (MediaTek):
		- * New proposal refers to TRP-to-panel channel correlation matrix RMIMO similarly to the agreed model.
			* New proposal does not explicitly define per-TRP channels statically independent, whereas the agreed model does.
			* New proposal is mathematically equivalent to the agreed model if we assume per-TRP channels statically independent:
* Proposals:
* Option 1 (MediaTek):
	+ - * Consider already agreed correlation model.
				+ Also fine to define channel model and spatial correlation matrix per TRP to UE if preferred by majority of companies.
* Option 2 (Apple):
	+ - * Define antenna configuration, channel model and spatial correlation matrix per TRP to UE.
			* Seek input from TE vendor on how the channel model and correlation matrix should be defined for multi-RX demod requirements.
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-10: Whether to adopt NT FR2 OTA enhancements when defining demodulation requirements.**

* Proposals
	+ Option 1 (MediaTek): Follow NR FR2 OTA enhancements WI work for their final conclusions and take those into account when defining corresponding demodulation requirements.
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-11: UE feature for joint processing (if introduced).**

* Observations
	+ Observation 1 (Apple):
		- It is FFS if requirements will be defined with joint processing.
* Proposals
	+ Option 1 (Apple):
		- If it is agreed to define requirements with joint processing introduce the separate UE capability for joint processing with sDCI SDM transmission scheme and joint processing with mDCI overlapping transmission scheme
		- If it is agreed to define requirements with joint processing introduce the following UE feature(s) -
			* UE capability for joint processing with sDCI SDM transmission scheme and/or UE capability for joint processing with mDCI overlapping transmission scheme
			* Optional without capability signaling
			* Pre-requisite FG: 16-2c: Simultaneous reception with different QCL Type-D
			* Granularity: Per FSPC.
	+ Option 2 (MediaTek): Consider the following.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Features** | **Index** | **Feature group** | **Components** | **Prerequisite feature groups** | **Need for the gNB to know if the feature is supported** | **Applicable to the capability signalling exchange between UEs (V2X WI only)”.** | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per** **FSPC)** | **Need of FDD/TDD differentiation** | **Need of FR1/FR2 differentiation** | **Capability interpretation for mixture of FDD/TDD and/or FR1/FR2** | **Note** | **Mandatory/Optional** |
| 30. NR\_FR2\_multiRX\_DL | 30-3 | Joint demodulation processing of multiple RX panels | Supports joint demodulation processing of multiple RX panels  | [30-1] | Yes | N/A | In scenarios with cross-talk between RX panels demodulation performance is worse | [Per band] | TDD only | FR2-1 only |  |  | Optional with capability signalling |

* + Option 3 (Ericsson): Introduce new UE receiver feature for FR2 multi-Rx reception, such as:
		- Multi-Rx simultaneous reception advanced receiver:
			* + Joint processing receiver with MIMO detector processing 4Rx and l1 + l2 layers across two TRPs
* Recommended WF:
	+ Encourage comments if any.

**Issue 1-1-12: TR update.**

* Observations
	+ Observation 1 (Apple):
* RAN4 has made significant progress in demodulation side and involves an evaluation phase before defining the requirements.
* In RAN#101 it was recommended to further discuss TRP update to capture demod evaluation in RAN4
	+ Observation 2 (Qualcomm):
* RAN4 is not conducting any exploratory demodulation studies in the context of FR2 multi-Rx WI.
* All performance requirements including the agreed FR2 multi-Rx correlation model will be captured in 38.101-4 specification.
* Proposals
	+ Option 1 (Apple, Nokia): Consider eexpanding the scope of TR 38.751
		- Option 1a (Apple): - Content of TR update: Correlation Matrix derivation/ definition; Performance evaluation of different configurations – cross talk levels, mTRP schemes, UE processing
		- Option 1b (MediaTek): Okay to consider expanding the scope of TR 38.751
	+ Option 2 (Huawei, Qualcomm): Don’t consider eexpanding the scope of TR 38.751.
* Recommended WF:
	+ Encourage comments if any.

# Topic #1: PDSCH Demodulation Requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318731 | Qualcomm | **Proposal 1: Confirm EPRE ratio to be state 0 for FR2 multi-Rx simulation assumptions.** **Proposal 2: Confirm that number of CDM groups without data is 2 for DMRS configuration.**  |
| R4-2318732 | Qualcomm | **Simulation Results** |
| R4-2318573 | Apple | **Multi-DCI transmission scheme**1. **Multi-DCI with non-overlapping PDSCH is not severely impacted by cross talk.**
2. **Multi-DCI with 1 layer per TRP overlapping PDSCH is not severely impacted by cross talk with separate processing.**
3. **Multi-DCI with 2 layers per TRP overlapping PDSCH is severely impacted by cross talk with separate processing.**
4. **For multi-DCI with 1 or 2 layers per TRP overlapping PDSCH, joint processing is more robust to cross talk.**
5. **Multi-DCI with overlapping PDSCH and 2 layers per TRP, only joint processing is feasible.**

**Single-DCI SDM transmission scheme**1. **Single-DCI SDM with 1 layer per TRP is not severely impacted by cross talk with separate processing.**
2. **Single-DCI SDM with 2 layers per TRP is severely impacted by cross talk with separate processing.**
3. **For single-DCI SDM with 1 or 2 layers per TRP, joint processing is robust to cross talk.**
4. **4 layer transmission with sDCI SDM is only possible with joint processing.**

**PDSCH requirements/ Simulation parameters**1. **Define PDSCH demodulation requirements with multi-RX in FR2 for multi-DCI with the following configuration:- PDSCH transmission: Fully overlapping- MCS/Layers: 1+1 – MCS 17- UE processing: Separate processing- FO/TO for TRP2: 600 Hz, -0.0625us- Cross talk power** $ρ$ **= -12dB**
2. **Define PDSCH demodulation requirements with multi-RX in FR2 for single-DCI SDM with the following configuration:- MCS/Layers: 1+1 – MCS 17- UE processing: Separate processing- FO/TO for TRP2: 600 Hz, -0.0625us- FO/TO for TRP2: 0 Hz, 0.25us- Cross talk power** $ρ$ **= -9dB**
3. **Prior to Rel-18, UE is not expected to receive PDCCH associated with different coresetPoolIndex simultaneously.**
4. **Configure PDCCH from each TRP non-overlapping in time for mDCI transmission mode.**
5. **PDCCH from TRP1 is transmitted on symbol 0 and PDCCH from TRP2 is transmitted on symbol 1 of the slot.**
6. **PDSCH transmission starts from symbol 2.**
7. **For sDCI SDM transmission scheme, PDCCH is transmitted on symbol 0 and PDCCH is transmitted from symbol 1.**
 |
| R4-2318571 | Apple | **Simulation Results**  |
| R4-2318572 | Apple | **DraftCR on PDSCH demod requirements for mDCI fully-overlapping with multi-RX in FR2** |
| R4-2318791 | Nokia | **Test cases and simulation parameters for mDCI fully-overlapping**1. **When separate processing is used, crosstalk interference can significantly reduce the demodulation performance for the mDCI fully-overlapping scenario for both 1+1 and 2+2 scenarios already from ρ = -12dB.**
2. **The simulation results obtained without the added impairments of time and frequency offset and with the addition of corresponding time and frequency offset combinations of (-0.0625us, 600Hz) and (0.25us, 0Hz) are identical for the agreed simulation configurations of mDCI fully-overlapping Rank 1+1 with MCS17 and Rank 2+2 with MCS13 using separate processing.**

Proposal 1: Use the time and frequency offset combination of (-0.0625us, 600Hz) for mDCI fully-overlapping simulations.Proposal 2: Define following test cases for mDCI fully-overlapping scenario with separate processing:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Layer combination | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition(Note 1) | Correlation matrix and antenna configuration(Note 2) | Time offest and frequency offset | Reference value |
| Fraction of maximum throughput (%) | SNR (dB)(Note 3) |
| **1-1** | **Rank 1+1** | **100 / 120** | **64QAM, 0.43** | **TDLA30-75** | **2x2 XPL** **(ρ = -12dB)** | **(-0.0625us, 600Hz)** | **70** | **TBD** |
| **1-2** | **Rank 2+2** | **100 / 120** | **16QAM, 0.48** | **TDLA30-75** | **2x2 XPL** **(ρ = -12dB)** | **(-0.0625us, 600Hz)** | **70** | **TBD** |
|  | **Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent****Note 2: Correlation matrix and antenna configuration parameters apply as defined in B.2.5****Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2** |

Proposal 3: Define the following test cases for mDCI fully-overlapping scenario with joint processing:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Layer combination | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition(Note 1) | Correlation matrix and antenna configuration(Note 2) | Time offest and frequency offset | Reference value |
| Fraction of maximum throughput (%) | SNR (dB)(Note 3) |
| **1-3** | **Rank 1+1** | **100 / 120** | **64QAM, 0.43** | **TDLA30-75** | **2x2 XPL** **(ρ = -6dB)** | **(-0.0625us, 600Hz)** | **70** | **TBD** |
| **1-4** | **Rank 2+2** | **100 / 120** | **16QAM, 0.48** | **TDLA30-75** | **2x2 XPL** **(ρ = -6dB)** | **(-0.0625us, 600Hz)** | **70** | **TBD** |
|  | **Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent****Note 2: Correlation matrix and antenna configuration parameters apply as defined in B.2.5****Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2** |

**Test cases and simulation parameters for mDCI non-overlapping**1. **The effect of crosstalk interference on the demodulation performance is still measurable for the mDCI non-overlapping scenario, but with much lower impact. To include the effect of the cross-talk for requirement definition a higher value of ρ can be selected.**

Proposal 4: Define following test cases for mDCI non-overlapping scenario with separate processing.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test num. | Layer combination | Bandwidth (MHz) / Subcarrier spacing (kHz) | Modulation format and code rate | Propagation condition(Note 1) | Correlation matrix and antenna configuration(Note 2) | Time offest and frequency offset | Reference value |
| Fraction of maximum throughput (%) | SNR (dB)(Note 3) |
| **1-5** | **Rank 2+2** | **100 / 120 (RB allocation: 32/32)** | **16QAM, 0.48** | **TDLA30-75** | **2x2 XPL** **(ρ = -6dB)** | **(-0.0625us, 600Hz)** | **70** | **TBD** |
|  | **Note 1: The propagation conditions apply to each of TRxP #1 and TRxP #2 and are statistically independent****Note 2: Correlation matrix and antenna configuration parameters apply as defined in B.2.5****Note 3: SNR corresponds to SNR of TRxP #1 and TRxP #2 as defined in 4.4.2** |

 |
| R4-2318792 | Nokia | **Simulation results.** |
| R4-2318794 | Nokia | **Draft CR for 38.101-4: Minimum requirements and Measurement Channel for mDCI non-overlapping** |
| R4-2318550 | MediaTek | **Proposal #1: Define epre-Ratio state ‘0’ for FR2 multipanel RX simulation assumptions.** |
| R4-2318551 | MediaTek | **Simulation results.****Observation #1: In fully overlapping schemes separate processing receiver assumption requires high isolation to work.****Observation #2: In fully overlapping schemes joint processing receiver assumption is robust with all simulated ρ values.****Observation #3: In fully overlapping schemes joint processing receiver assumption performance is better with higher isolation.****Observation #4: In non-overlapping schemes joint processing receiver assumption in low isolation gives diversity gain.** |
| R4-2318551 | MediaTek |  |
| R4-2319743 | Ericsson | **Proposal 1: Consider the following PDSCH demodulation requirements with sDCI-based SDM scheme.** **1+1, MCS17, ρ=-6dB, FO/TO=600Hz/-0.0625us****2+2, MCS13, ρ=-12dB, FO/TO=0Hz/0.25us****Proposal 2: Define two PDSCH demodulation requirements: one with separate processing and another with joint processing, at least for the sDCI-based SDM transmission with 1+1 MCS17 rho=-6dB case.****Proposal 3: Introduce new UE receiver feature for FR2 multi-Rx reception, such as:****Multi-Rx simultaneous reception advanced receiver:****Joint processing receiver with MIMO detector processing 4Rx and l1 + l2 layers across two TRPs****Proposal 4: Define the following PDSCH demodulation requirements with mDCI-based full-overlapping scheme.****1+1, MCS17, ρ=-12dB, FO/TO=0Hz/0.25us****Proposal 5: Define single PDSCH demodulation requirement assuming separate processing for multi-DCI based full-overlapping scheme as far as rho=-12dB.****Proposal 6: Define the following PDSCH demodulation requirements with mDCI-based non-overlapping scheme.** **2+2, MCS13, ρ=-12dB, FO/TO=600Hz/-0.0625us****Proposal 7: Define single PDSCH demodulation requirements assuming separate processing for multi-DCI based non-overlapping scheme.** |
| R4-2319744 | Ericsson | **Simulation results.** |
| R4-2320235 | Huawei | **Draft CR on Minimum requirements and FRC definition for sDCI SDM** |

## Open issues summary

List of open issues

* Sub-topic 2-1 Simulation assumptions for PDSCH demodulation requirements
	+ Issue 2-1-1: PTRS EPRE ratio
	+ Issue 2-1-2: Number of DMRS CDM groups without data
	+ Issue 2-1-3: Time/frequency offsets for sDCI SDM
	+ Issue 2-1-4: Time/frequency offsets for mDCI fully overlapping.
	+ Issue 2-1-5: Time/frequency offsets for mDCI non overlapping.
	+ Issue 2-1-6: General PDSCH/PDCCH configuration for mDCI
	+ Issue 2-1-7: General PDSCH/PDCCH configuration for sDCI

### Sub-topic 2-1: Simulation assumptions for PDSCH demodulation requirements

**Issue 2-1-1: PT-RS EPRE Ratio**

* Proposals
* Option 1 (Qualcomm, MediaTek): Define EPRE-Ratio state ‘0’ for FR2 multi-panel RX simulation assumptions.
* Recommended WF:
	+ Option 1

**Issue 2-1-2: Number of DMRS CDM groups without data**

* Proposals
	+ Option 1 (Qualcomm):
		- Confirm that the number of CDM groups without data is 2 for DMRS configuration.
* Recommended WF:
	+ Encourage comments if any.

**Issue 2-1-3: Time/frequency offsets for sDCI SDM**

* Proposals
	+ Option 1 (Apple):
* 1+1 – MCS 17, FO/TO for TRP2: 600 Hz, -0.0625us
	+ Option 2 (Ericsson):
		- 1+1, MCS17, ρ=-6dB, FO/TO=600Hz/-0.0625us
		- 2+2, MCS13, ρ=-12dB, FO/TO=0Hz/0.25us
* Recommended WF:
	+ Encourage comments if any.

**Issue 2-1-4: Time/frequency offsets for mDCI fully overlapping.**

* Observations
* Observation 1 (Nokia):
	+ - When separate processing is used, crosstalk interference can significantly reduce the demodulation performance for the mDCI fully-overlapping scenario for both 1+1 and 2+2 scenarios already from ρ = -12dB.
		- The simulation results obtained without the added impairments of time and frequency offset and with the addition of corresponding time and frequency offset combinations of (-0.0625us, 600Hz) and (0.25us, 0Hz) are identical for the agreed simulation configurations of mDCI fully-overlapping Rank 1+1 with MCS17 and Rank 2+2 with MCS13 using separate processing.
* Proposals
	+ Option 1 (Nokia, Apple): -0.0625us, 600Hz.
		- Option 1a (Apple): for 1+1 – MCS 17
	+ Option 2 (Ericsson): 0.25us, 0Hz
* Recommended WF:
	+ Encourage comments if any.

**Issue 2-1-5: Time/frequency offsets for mDCI non overlapping.**

* Observations
* Observation 1 (Nokia):
	+ - The effect of crosstalk interference on the demodulation performance is still measurable for the mDCI non-overlapping scenario, but with much lower impact. To include the effect of the cross-talk for requirement definition a higher value of ρ can be selectedProposals
* Proposals
	+ Option 1 (Nokia, Ericsson): -0.0625us, 600Hz
* Recommended WF:
	+ Encourage comments if any.

**Issue 2-1-6: General PDSCH/PDCCH configuration for mDCI**

* Observations
* Observation 1 (Apple):
	+ Prior to Rel-18, UE is not expected to receive PDCCH associated with different coresetPoolIndex simultaneously.
* Proposals
	+ Option 1 (Apple):
		- Configure PDCCH from each TRP non-overlapping in time for mDCI transmission mode.
		- PDCCH from TRP1 is transmitted on symbol 0 and PDCCH from TRP2 is transmitted on symbol 1 of the slot.
		- PDSCH transmission starts from symbol 2
* Recommended WF:
	+ Encourage comments if any.

**Issue 2-1-7: General PDSCH/PDCCH configuration for sDCI SDM**

* Observations
* Observation 1 (Apple):
	+ Prior to Rel-18, UE is not expected to receive PDCCH associated with different coresetPoolIndex simultaneously.
* Proposals
	+ Option 1 (Apple):
		- Proposal #6: For sDCI SDM transmission scheme, PDCCH is transmitted on symbol 0 and PDCCH is transmitted from symbol 1.
* Recommended WF:
	+ Encourage comments if any.

# Topic: CSI Reporting Requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc** **number** | **Company** | **Proposals / Observations** |
| R4-2318754 | Apple | 1. **Define antenna configuration as 2x4 XP per TRP-UE, with 2 panels with 2RX each at UE.**
2. **For PMI reporting with multi-RX, introduce requirements with separate processing.**
3. **Introduce requirements with =9dB cross talk ratio for PMI reporting.**
 |
| R4-2318793 | Nokia | **Simulation parameters for PMI reporting requirement for sDCI SDM scheme**1. **We see “XP 2x4 (N1,N2) = (2,1), (4 antenna at UE across 1 panel)” to have better performance compared to “XP 2x4 (Ng,N1,N2) = (2,1,1) (4 antenna at UE across 2 panels)” as it has more flexibility.**
2. RAN4 to adapt XP 2x4 (N1,N2) = (2,1), (4 antenna at UE across 1 panel) for antenna configuration when defining PMI requirements.

**Reference Channel**1. Reuse the reference channel from TS38.101-4, section 6.3.2.1.7 with adaptation to 4 ports as starting point. Configure the codebook for 1 panel option.
 |
| R4-2319745 | Ericsson | **Proposal 1: Set test point to the SNR achieving 90% of peak rate with follow PMI.** **Proposal 2: Set MCS11 2+2 for PDSCH FRC.** **Proposal 3: Set FO=0Hz and TO=0us for PMI reporting test.** |
| R4-2320234 | Huawei | 1. Select 90% of the maximum throughput for FR2 multi-Rx PMI reporting requirements.
2. Select γ = 1.3 as the test metric.
3. Select MCS13 for FR2 multi-Rx PMI reporting requirements.
4. Use reference channels as Table 2.3-1 for FR2 multi-Rx PMI reporting requirements.

Table 2.3-1 Reference channels for FR2 multi-Rx PMI reporting requirements

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Unit** | **1 PTRS port** | **2 PTRS port** |
| **Channel bandwidth** | **MHz** | **100** | **100** |
| **Subcarrier spacing** | **kHz** | **120** | **120** |
| **Allocated resource blocks** | **PRBs** | **66** | **66** |
| **Number of consecutive PDSCH symbols** |  | **12** | **12** |
| **Allocated slots per 2 frames** |  | **63** | **63** |
| **MCS table** |  | **64QAM** | **64QAM** |
| **MCS index** |  | **13** | **13** |
| **Modulation** |  | **16QAM** | **16QAM** |
| **Target Coding Rate** |  | **0.48** | **0.48** |
| **Number of MIMO layers** |  | **2** | **2** |
| **Number of DMRS REs (Note 3)** |  | **24** | **24** |
| **Overhead for TBS determination** |  | **6** | **12** |
| **Information Bit Payload per Slot**  |  |  |  |
|  **For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
| **For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
|  **For Slot i = 80** | **Bits** | **28680** | **27144** |
|  **For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159}** | **Bits** | **28680** | **27144** |
| **Transport block CRC per Slot** |  |  |  |
|  **For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
| **For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
|  **For Slot i = 80** | **Bits** | **24** | **24** |
|  **For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159}** | **Bits** | **24** | **24** |
| **Number of Code Blocks per Slot** |  |  |  |
|  **For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159}** | **CBs** | **N/A** | **N/A** |
| **For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159}** | **CBs** | **N/A** | **N/A** |
|  **For Slot i = 80** | **CBs** | **4** | **4** |
|  **For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159}** | **CBs** | **4** | **4** |
| **Binary Channel Bits Per Slot** |  |  |  |
|  **For Slots 0 and Slot i, if mod(i, 5) = {3,4} for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
| **For CSI-RS Slot i, if mod(i,5) =1 for i from {0,…,159}** | **Bits** | **N/A** | **N/A** |
|  **For Slot i = 80** | **Bits** | **57648** | **55008** |
|  **For Slot i, if mod(i, 5) = {0,2} for i from {1,…,79,82,…,159}** | **Bits** | **60720** | **58080** |
| **Max. Throughput averaged over 2 frames** | **Mbps** | **90.342** | **90.342** |
| **Note 1: SS/PBCH block is transmitted in slot #0 with periodicity 20 ms****Note 2: Slot i is slot index per 2 frames****Note 3: Number of DMRS REs includes the overhead of the DM-RS CDM groups without data** |

 |
| R4-2318552 | MediaTek | **Proposal #1: We are open to consider joint processing receiver assumption for PMI reporting requirements if UE capability for joint processing is introduced.****Proposal #2: We propose to finalize correlation model discussion first and define antenna configuration accordingly.****Proposal #3: Set test metric as γ=tue/trnd, where tue is 90% of the maximum throughput obtained at SNRue using the precoders configured according to the UE reports, and trnd is the throughput measured at SNRue with random precoding.****Proposal #4: We propose to use MCS13 in PMI reporting requirements.** |
| R4-2318553 | MediaTek | **Simulations results** |
| R4-2318554 | MediaTek | **Draft CR to 38.101-4 PMI requirements of FR2 multiRX DL** |
| R4-2318555 | MediaTek | **Draft CR to 38.101-4 PMI reference measurement channel of FR2 multiRX DL** |

## Open issues summary

List of open issues

* Sub-topic 3-1 Simulation assumptions
	+ Issue 3-1-1: Antenna configuration
	+ Issue 3-1-2: Receiver assumption for PMI Reporting
	+ Issue 3-1-3: MCS
	+ Issue 3-1-4: Time/frequency offsets for PMI reporting
	+ Issue 3-1-5: Performance Metric
	+ Issue 3-1-6: Throughput ratio (γ) value
	+ Issue 3-1-7: Reference Channel

### Sub-topic 3-1: Simulation assumptions

**Issue 3-1-1: Antenna Configuration**

* Observations
	+ Observation 1 (Nokia): “XP 2x4 (N1,N2) = (2,1), (4 antenna at UE across 1 panel)” to have better performance compared to “XP 2x4 (Ng,N1,N2) = (2,1,1) (4 antenna at UE across 2 panels)” as it has more flexibility.
* Proposals
	+ - Option 1 (Apple): Define antenna configuration as 2x4 XP per TRP-UE, with 2 panels with 2RX each at UE.
		- Option 2 (Nokia): RAN4 to adapt XP 2x4 (N1,N2) = (2,1), (4 antenna at UE across 1 panel) for antenna configuration when defining PMI requirements.
		- Option 3 (MediaTek): We propose to finalize correlation model discussion first and define antenna configuration accordingly.
* Recommended WF:
	+ Encourage comments if any.

**Issue 3-1-2: Receiver assumption for PMI Reporting**

* Proposals
	+ - * Option 1 (Apple): Consider separate processing for PMI reporting with sDCI SDM transmission with -9dB crosstalk power ratio.
			* Option 2 (MediaTek): Open to consider joint processing receiver assumption for PMI reporting requirements if UE capability for joint processing is introduced.
* Recommended WF:
	+ Encourage comments if any.

**Issue 3-1-3: MCS**

* Proposals
	+ Option 1 (Ericsson): MCS11 with 2+2.
	+ Option 1 (MediaTek, Huawei): MCS13 with 1+1.

Moderator’s note: It was agreed to only consider 1+1 case for PMI reporting with sDCI SDM (RAN4#106-bis-e)

* Recommended WF:
	+ Encourage comments if any

**Issue 3-1-4: Time/frequency offsets for PMI reporting**

* Proposals
	+ Option 1 (Ericsson): Set FO=0Hz and TO=0us for PMI reporting test.
* Recommended WF:
	+ Option 1

**Issue 3-1-5: Performance Metric**

* Proposals
	+ Set test metric as γ=t\_ue/t\_rnd , where t\_ue is [X] % of the maximum throughput obtained at SNR\_ue using the precoders configured according to the UE reports, and t\_rnd is the throughput measured at SNR\_ue with random precoding.
		- Option 1 (Huawei): X=70%
		- Option 2 (Ericsson, MediaTek): X=90%
* Recommended WF:
	+ Encourage comments if any.

**Issue 3-1-6: Throughput ratio (γ) value**

* Proposals
	+ Option 1 (Huawei): Consider γ = 1.3.
* Recommended WF:
	+ Encourage comments if any.

**Issue 3-1-7: Reference Channel**

* Proposals
	+ Option 1 (Huawei): Use reference channels as presented in Table 2.3-1 for FR2 multi-Rx PMI reporting requirements.
	+ Option 2 (Nokia): Reuse the reference channel from TS38.101-4, section 6.3.2.1.7 with adaptation to 4 ports as starting point. Configure the codebook for 1 panel.
* Recommended WF:
	+ Encourage comments if any.

# CRs

Following draft CRs are available for considerations.

|  |  |  |  |
| --- | --- | --- | --- |
| **Section number** | **Section title** | **Responsible company** | **Status** |
| **TS 38.101-4** |  |
| **R4-2321016** | **Draft Big CR on UE demodulation and CSI performance requirements for FR2 multi-Rx** | **Qualcomm** | **Reserved** |
| **5.1.1.8** | **Applicability of requirements (if any)** | **Samsung** | **If needed** |
| **R4-2318767** | **DraftCR to include the FR2 multi-Rx correlation model in the 38.101-4 specification** | **Qualcomm** | **Available** |
| **R4-2320235** | **Draft CR on Minimum requirements and FRC definition for sDCI SDM** | **Huawei** | **Available** |
| **R4-2318794** | **Draft CR for 38.101-4: Minimum requirements and Measurement Channel for mDCI non-overlapping** | **Nokia** | **Available** |
| **R4-2318752** | **DraftCR on PDSCH demod requirements for mDCI fully-overlapping with multi-RX in FR2** | **Apple** | **Available** |
| **R4-2318554** | **Draft CR to 38.101-4: PMI reporting requirements for FR2 multipanel reception** | **MTK** | **Available** |
| **R4-2318555** | **Draft CR to 38.101-4: PMI reference measurement channel for FR2 multipanel reception** | **MTK** | **Available** |